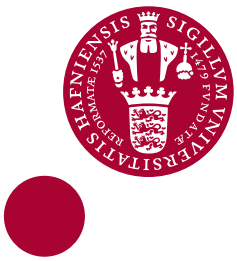

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Open Peer Commentary on "**The plasticity of the bodily self: the special status of head movements in full-body illusions and how they relate to Gallagher's body image and body schema**" by Marte Roel Lesur, Michael Gaebler, Philippe Bertrand, and Bigna Lenggenhager.

Sense of Ownership and Sense of Agency in First-Person-Perspective Full-Body Illusions

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Upshot: In my commentary, I raise some questions about the applicability of Gallagher's distinction between body image and body schema to the experimental research reported and discussed in the target article. I suggest that the distinction between body image and body schema is of limited help in this context, and that Gallagher's distinction between sense of ownership and sense of agency provides a more natural and fruitful theoretical framework to discuss that research.

1. The possibility of inducing illusions of bodily ownership and bodily agency over foreign limbs and full foreign bodies has given rise to a thought-provoking literature about the constituents and malleability of the human sense of bodily self. Marte Roel et al.'s target article illustrates nicely how the experimental manipulation of sensorimotor signals, in tandem with technological advances, enables an increasingly fine-grained investigation of the bodily self, and in particular of the role that different sensorimotor factors play in bodily illusions. The authors focus on two types of illusions: the illusory limb identification (ILI) (§3) – a paradigm of which is the rubber hand illusion – and first-person perspective full-body illusions (1PP FBI) (§4), in which a subject wearing a head-mounted display gains virtual access to the perceptual and embodied perspective of someone else. While I agree with the authors that investigating different types of bodily signals during bodily illusions can shed light on the sense of bodily self, I have reservations about the way in which they link their discussion with Shaun Gallagher's distinction between body image and body schema. I will briefly suggest that Gallagher's distinction between sense of ownership and sense of agency could be more fruitfully applied to the empirical research discussed in the target article.

2. A central claim of the target article is that during 1PP FBIs, head-related sensorimotor signals have a special status with respect to limb-related signals. The authors provide preliminary support for this hypothesis by building on the work of Antonella Maselli, Mel Slater, and collaborators (Maselli & Slater 2013; Maselli et al. 2016). According to these authors, during a 1PP FBI, asynchronous visuotactile stimulation of a peripheral limb does not affect the illusion (§6). This stands in contrast to ILI, in which temporally coherent stimulation has been shown to be a necessary condition for the illusion to occur (i.e., the rubber hand has to be touched synchronously with the participant's hand in order for the illusion to take place) (§5). In the empirical

study reported in the article, the authors extend the experimental paradigm employed by Maselli et al., by involving live videos of another person instead of computer-generated characters (§§7, 18). They also advance a more specific hypothesis concerning the discrepancy between ILI and 1PP FBIs with respect to temporally incoherent stimulation. Whereas Maselli et al. suggest that the feeling of ownership over a complete foreign body, as it happens in 1PP FBIs, allows for the integration of mismatching sensorimotor cues, the authors claim that head-related sensorimotor signals are the crucial binding factor that supports the robustness of the illusion (§10). It is worth noting, though, that the experimental findings reported in the article do not provide direct support for this tentative hypothesis (§29, 30), but rather for the hypothesis (advanced already by Maselli & Slater 2013) that asynchronous visuotactile stimulation does not reduce the feeling of body ownership during 1PP FBIs (§20).

3. Now, suppose that this hypothesis is on the right track. Would Gallagher's distinction between body image and body schema shed light on it? According to the authors, it would. The body image, according to Gallagher, is the body as perceived and, more generally, as intended (perceptually, cognitively, and also emotionally). In contrast, the body schema refers to the body as operative without perceptual monitoring, and more generally, without being intended (for example, in the postural adjustments that guide action execution). Consider now how the authors apply that distinction to the bodily illusions discussed in the article. They write that

> "[d]uring both ILI and 1PP FBIs, it is the *body percept* that is initially manipulated when participants look at their new bodies or limbs; their perceptual experience becomes determined by another limb/body." (§22)

4. Is this analysis convincing? In ILI, the experimental subject attends perceptually to the limb that is being stimulated, so the perceived body is directly involved. However, the situation appears to be more complex in 1PP FBIs. In the context of this illusion, the way in which a new body determines the participant's perceptual experience is not the same as in ILI. As the authors write, "[t]he particularity of the 1PP FBI is that both the whole body *and the perceptual field of the participant* are visually exchanged with that of the illusion." (§4, my emphasis). If this is right, what is manipulated during 1PP FBIs is not in the first place the perceived body, but rather the lived body from which the participant can virtually access and thematically focus on, amongst other things, parts of her "new" body. No doubt, looking at parts of her "new" body during a 1PP FBI might be relevant for the participant for different reasons (such as helping the participant to become familiar with it), but that would only be possible because the participant's perceptual field has been exchanged with that of the illusion.

5. Let me now briefly comment on the concept of the body schema, in connection with the hypothesis that head-related signals have a special status in 1PP FBIs. It seems to me that the authors overlook the extent to which bodily schematic capacities are involved in head movements, and thereby the tacit contribution that the body schema makes to such movements. Consider again the 1PP FBI scenario. The participant is now embodying another person's perspective. Suppose, moreover (and more speculatively), that head-related sensorimotor coherences have a special status in sustaining the

illusion. How could they have such special status? It would be implausible to say that those movements become integrated into the participant's body image, since there is no thematic perception of the head or its movements during the illusion. At this point, Gallagher's characterization of the body schema in terms of "a capacity to move (or an ability to do something)" (quoted in §21) might be of help. After all, is this capacity to move not what is modulated in the first place, when participants can freely move their heads in 1PP FBIs? That seems to be the case. Therefore, I suggest that the bodily schematic significance of head movements in 1PP FBIs puts pressure on the authors' proposal that "[m]anipulations of body image could be considered the most important aspect of 1PP FBIs," and on their contention that "if the body image is manipulated to a certain degree […] then the body schema changes." (§24).

6. Ultimately, I think that the distinction between body image and body schema is of limited help in illuminating the experimental research discussed by the authors. The main reason is that the issue of whether the body is thematically or non-thematically present in the participants' experience is not a central concern in the discussion on bodily illusions carried out in the article. However, that issue is arguably at the heart of the body image/body schema distinction.

7. A different path, which I will only sketch here, would be to focus on the distinction between a bodily sense of ownership and a bodily sense of agency, i.e., the distinction between experiencing a body (and its movements) as one's own, and experiencing oneself as the cause or initiator of an action (Gallagher 2017). This distinction is mentioned in passing in the article, as the one between "the *feeling of ownership* (the experience of the body being one's own) and the *feeling of agency* (the experience of self-generating an action), which have been argued to be the most crucial aspects of the bodily self" (§1). If the authors agree that these are the most crucial aspects of the bodily self, would it not be more natural to discuss the empirical research in connection with that distinction, instead of focusing somewhat narrowly on the distinction between body image and body schema?

8. I conclude by offering some additional reasons why a focus on the distinction between sense of ownership and sense of agency would be particularly relevant to the discussion carried out in the article:

a. Several items of the questionnaire used in the empirical study reported in the article directly concern "body ownership" and "agency" (§7).
b. The distinction between sense of ownership and sense of agency is implicit in the two main experimental conditions of the study presented in the article (visuotactile and visuomotor conditions) (§18).
c. Applying that distinction to the hypothesis advanced in the article concerning the special status of head movements in 1PP FBIs could add an interesting twist to this hypothesis: one might consider the possibility that if head movements have a special status in 1PP FBIs, this is at least partly because they are active and voluntary movements, in which participants exercise their sense of agency. To put it briefly, these movements are something that participants *do*, and not

something that they just passively register (as is the case with the sensory stimulation in ILI).

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